Abstract No. ivan680

High-Energy Characterization of Multilayers for Hard X-Ray Astronomy

A. Ivan, (Smithsonian Astrophysical Observatory and MIT), R. Bruni (Smithsonian Astrophysical Observatory) S. Cenko (Harvard U. and Smithsonian Astrophysical Observatory), P. Gorenstein and S. Romaine (Smithsonian Astrophysical Observatory)

Beamline(s): X17B1

Introduction: The imaging of astrophysical objects in the hard X-ray band (above 10 keV) with high angular resolution requires coating of Wolter Type I optics with multilayers. For broadband reflectivity the multilayers are designed with a depth grading of the period. The practical problem of producing multilayers based on a design involves the selection of the materials and of the coating process, as well as measuring their reflectivity at high energies to provide feedback for optimization of the process.

Methods and Materials: Magnetron sputtering was used as the deposition process for several advantages: large area coating capability, low substrate temperature, process stability and reproducibility. The materials selected for the multilayers were W/Si, Pt/C, Mo/Si, and W/C. The substrates used in these measurements were silica flats and silicon wafers. We have used the X17B1 Beamline to perform specular reflectivity measurements in the range 30-80 keV.

Results: By performing reflectivity measurements at the energies at which the x-ray mirrors will operate we tested the quality of the multilayer coatings and determined what type of deviations from the design is present for each material system. The first type of measurement scans the incidence grazing angle at a fixed beam energy and covers a dynamic range of $1:10^{-6}$ in reflectivity (Fig.1). The measured data are compared with a model reflectivity and parameters like thickness and interface roughness can be fitted with the IMD software [1]. The second type of measurement is relevant for operating as telescope mirrors. The grazing incidence angle is fixed and the energy of the beam is scanned (Fig.2).

Conclusions: The analysis allowed to determine non-destructively the structure of multilayers with up to 350 bilayers and to validate the design thicknesses and deposition rates. The interface widths due to roughness and diffuseness were determined from fit and were in the range 3.5 to 5 Angstroms r.m.s., varying according to the materials used in the multilayers and the deposition conditions. W/Si displayed a high enough reflectivity in a wide energy bandpass, at grazing angles that are of interest for future work with x-ray telescope mirror shells. The data showed reflectivity of 30% at 60 keV for a grazing angle of 15 arcmin on the best W/Si multilayer (see [2]). Future work will include fully optimized coatings and pencil beam reflectivity measurements on telescope prototype shells.

References:

[1] D.L. Windt, “IMD: Software for modeling the optical properties of multilayer films,” Computers in Physics, vol.12, 1998, p.360-370.

[2] A. Ivan, R. Bruni, S. Cenko, P. Gorenstein, S. Romaine, (invited paper), Proc. SPIE Annual Meeting, vol. 4496, San Diego, CA, 2001.

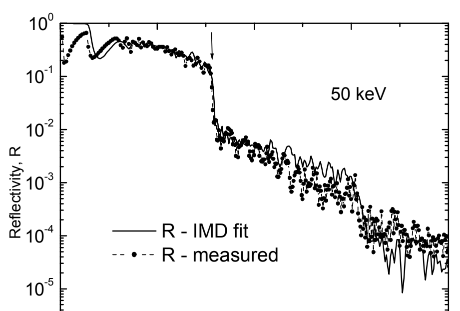

Fig.1: X-ray reflectivity vs. grazing angle scan for a W/Si multilayer with N=350 bilayers and graded period. The solid line represents the model and the measured data are represented by dots connected with a dash line.

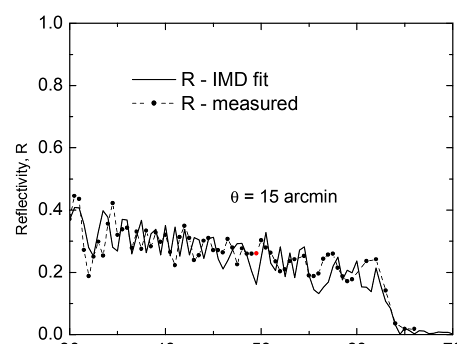

Fig.2: X-ray reflectivity vs. energy for a fixed grazing incidence angle of 15 arcmin for the sample described in Fig.1. The model showed an average interface roughness of 4 Angstroms r.m.s.